LARGE SCALE REARING OF HORN FLIES ON CATTLE

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LARGE-SCALE REARING OF HORN FLIES ON CATTLE

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ABSTRACT

Improved procedures for rearing horn flies, *Haematobia irritans* (L.), on steers were developed. Adult horn flies were maintained on steers and allowed to oviposit directly on the feces from the steers. The feces containing the eggs were combined with an artificial larval-rearing medium, which increased the survival and size of the resulting pupae. The various procedures developed during the study resulted in an average daily production of 24,800 pupae from about 6,500 flies on each steer. A production of 1 million pupae per week from six steers, requiring the labor of two people, seemed feasible.

INTRODUCTION

The release of sterile male horn flies, *Haematobia irritans* (L.), into natural populations may help eradicate this pest. A primary requirement of eradication by the release of sterile males is an adequate supply of vigorous, competitive insects. Research on the sterilization and release of horn flies at the U.S. Livestock Insects Laboratory, Kerrville, Tex., required a facility capable of producing about 1 million horn flies per week. The purposes of this study were to develop methods for rearing such quantities of flies without excessive labor and to produce flies that survived well in natural environments.

Horn flies were successfully maintained on cattle in the laboratory by Depner[3] and Harris.[4] Hargett and Goulding [5] surmised that a host animal could support 10,000 adults and produce at least 50,000 new adults daily. Horn flies have been reared in laboratory cages without cattle, but the handling and feeding of the adults requires substantial labor. [6] Also, the more natural environments on cattle may result in more vigorous and competitive offspring. For these reasons, this study was performed with adult horn flies maintained on steers.

MATERIALS AND METHODS

The rearing facility was a metal storage shed with a concrete floor and plywood-lined walls and ceiling. The building was partitioned into a 19- by 12-foot adult-rearing room, housing a steer, and two smaller rooms for rearing larvae and separating pupae from the larval-rearing medium. The building was air conditioned to maintain temperatures at 70° to 80° F. Light in

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[3] Depner, K. R. 1962, Continuous propagation of the horn fly, *Haematobia irritans* (L.) (Diptera: Muscidae). Can. Entomol. 94(8): 893–895.

[4] Harris, R. L. 1962. Laboratory colonization of the horn fly, *Haematobia irritans* (L.). Nature (London) 196(4850): 191–192.

[5] Hargett, L. T., and Goulding, R. L. 1962. Rearing the horn fly, *Haematobia irritans* (L.). J. Econ. Entomol. 55 (4): 565–566.

[6] Schmidt, C. D., Harris, R. L., and Hoffman, R. A. 1967. Mass rearing of the horn fly, *Haematobia irritans* (Diptera: Muscidae), in the laboratory. Ann. Entomol. Soc. Am. 60 (3): 508–510.

——— 1968. New techniques for rearing horn flies at Kerrville, 1967. Ann. Entomol. Soc. Am. 61 (4): 1045–1046.

the adult-rearing room was provided by four 40-watt fluorescent lamps.

A hereford steer, weighing 1,000 pounds or more, was used for about 6 weeks before being replaced by a fresh animal. The steer was held in a stanchion and stall on an 8-inch-high platform. The stanchion could be adjusted so that most of the droppings fell clear of the platform onto plastic sheets or into containers on the floor. The height of the platform stopped the steer from stepping into the droppings. The platform was sloped so that urine drained away from the droppings, and during the study, a continuously flushing urinal was installed to remove urine. The steer was fed alfalfa hay ad libitum, mineral supplement, and occasionally wheat bran. Water was always available.

The adult horn flies were allowed to oviposit directly on the droppings. Much of the experimentation was concerned with the handling of these droppings and the immature stages of horn flies within them. Pupae were separated from the larval media by agitation in water. The dispersed particles of medium tended to sink, and the floating pupae were removed. Cleaned pupae were weighed, and the weight of a separate 100-pupae sample was used to estimate the mean pupal weight and the total number of pupae for each day or for each larval container. Other measures used to indicate the success of experimental treatments included adult population counts, percent eclosion of pupae, and density of pupae in the media.

The research performed in this study can be divided into three parts. During the winter of 1970–71, preliminary experiments were performed to determine the effects of certain environmental factors, to compare various containers for collecting feces and rearing larvae, and to determine the value of supplementing the feces from the steer with additional feces. The second part of the study was concerned with improving the larval media by addition of artificial rearing medium to the feces. The third part of the study was a production test incorporating the best procedures determined from earlier tests.

RESULTS

Preliminary Experiments

Data from these experiments are summarized in table 1. During period 1, strong odors and ammonia fumes existed in the rearing facility. On two occasions, the flies were observed ovipositing in the hair of the steer rather than on the droppings. Installation of a continuously flushing urinal reduced the odors, and the oviposition habits of the flies became more normal during period 2. The increased production of pupae during period 2 was credited to increased oviposition and higher adult populations, but both factors may have been influenced by the reduction of odors. The increased production of pupae during period 2, as compared to period 1, seemed to be associated with a reduction of pupal weight from 3.44 to 3.04 milligrams. This relation was tested by performing a regression of mean pupal weight versus pupal density of each rearing pan for the data collected during periods 1 and 2. The regression equation had a Y-intercept of 3.808 milligrams, a slope of −0.763 milligrams per pupae per gram of feces,

TABLE 1.—*Summary of pupal production, preliminary experiments, October 29, 1970, to May 26, 1971*

Period	No. days	Feces wt., kg/day	No. pupae/day	Pupal wt.,[1] mg	Pupal density, No./g feces	Pupal release rate, No./day	Adult Population, No.	Emergence, percent
1	26	12.0	2,645	3.44	0.22	1,572	(2)	(2)
2	25	12.0	7,025	3.04	.59	1,884	(2)	(2)
3	42	[3] 18.1	5,022	3.24	.27	1,744	(2)	(2)
4	63	[3] 14.3	4,588	3.46	.34	1,171	1,621	58.0
5	54	17.4	10,063	3.12	.58	1,056	3,164	64.5

[1] of pupal weight was calculated on the basis of per pupa, not per pan or per day.

ces that were added for certain tests.

n F-statistic of 37.61 (significant at I1). The decrease in pupal weight at the population densities indicated that the from one steer were inadequate under rticular rearing conditions.

ing period 3, extra feces from a fly-free were added to the colony steer droppings termine if pupal weight and production be increased by reducing the population ty of the larvae. On 12 different days, which were collected overnight or occa-lly during the day, were divided into 2 parts, with the extra feces being added to rt. The differences between mean pupal t and mean number of pupae were tested paired t-test, with the results in table 2. The d feces resulted in significantly heavier e, but substantially reduced the numbers of e. Observation of the rearing pans indicated the larvae were using only the outer 1- to h layer of feces, suggesting that the depth ld be reduced to better utilize the medium.

uring period 4, several different attempts e made to increase the numbers and size of ae by improving larval-handling procedures. variation was the use of trays with wire-h bottoms. In some cases, these trays were ed over shallow pans filled with water to vent excessive drying of the medium. Gener-, the trays with the wire-cloth bottoms pro-ed greater numbers of pupae without the responding reduction in pupal weight result-with pans or trays with solid bottoms. The lition of extra feces again resulted in heavier pae, but a substantial reduction in the num-s of pupae. Other comparisons of the sizes d times of feces collections failed to show any bstantial improvements in pupal production.

BLE 2.—*Pupal production with and without added feces*

eatment	Feces wt., kg/pan	No. pupae/ pan[1]	Pupal wt.,[2] mg	Pupal density, No./g feces
o added feces	4.8	4,088	2.69	0.86
ith added feces	9.9	2,360	3.68	.24

[1] Significantly different at P=0.1.
[2] Significantly different at P=0.01.

During periods 2, 3, and 4, adult survival seemed to be very low. Many of the newly emerged flies could not fly or were unable to reach the steer and feed. During period 4, extensive counts of adult population indicated an average population of only 1,621 flies, despite a daily release rate of 1,171 pupae. If 58 percent of the released pupae eclosed, as indicated by emergence samples, then the average life of the emerged flies was only 2.4 days.

During period 5, the daily production of pupae was 10,063, substantially higher than in previous periods. Several factors may have contributed to this increased production. Larvae were reared in the trays with wire-cloth bottoms, which seemed to promote better survival, as indicated by earlier tests. Some of the larval trays were left in the room containing the steer until substantial number of adults had emerged. These flies may have been more vigorous because they were not subjected to the agitation and flotation process as pupae. Adult survival may have been further improved by lowering the room temperature from 80° to 75° F and by eliminating a fogging nozzle used earlier for maintaining humidity in the room containing the steer. Also, the steer was fed more than previously and produced a larger quantity of feces for larval rearing.

On five different days during period 5, the production of pupae exceeded 20,000 and once was 27,314. These figures indicated that the average daily production of 10,063 pupae could be greatly increased if certain limiting factors could be eliminated. One major factor was the amount of feces available from the steer. Over-crowding of the larvae could result in both higher mortality as larvae and low vigor in those that survive as adults. The effect of overcrowding on pupal size is shown by the solid line in figure 1, which shows the decrease in pupal weight with increasing population density. Before production of pupae from one steer could be increased much above 10,000, a method for supplementing the feces with additional feces or artificial media seemed necessary.

Another factor which seemed to limit pupal production was the inability to maintain the adult populations above about 5,000 flies on the steer. This factor appeared to be partially due to poor vigor of newly emerged adults because of the larval-rearing conditions. Also, the stall and platform used for the 1971 experiments were

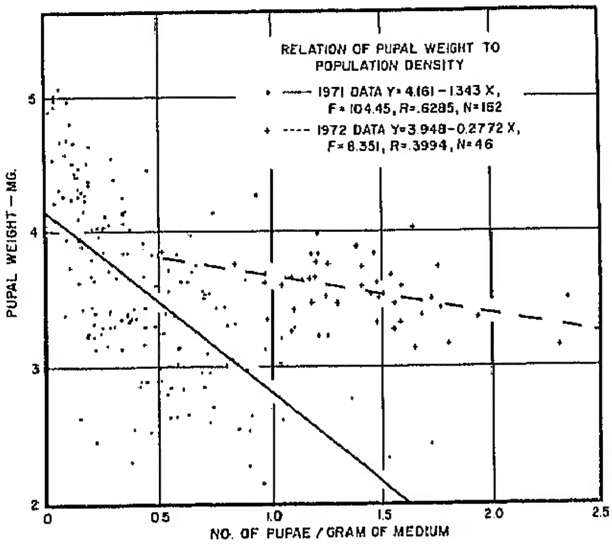

FIGURE 1.—Relation of pupal weight to the population density of the pupae.

discovered to have crevices containing decaying hay. The emitted gases may have been harmful to the adult flies.

Improvement of Larval Medium

Research performed during the winter of 1971–72 was devoted to improvement of the larval medium by adding a dry artificial medium. During this period the steer was clipped every week, which seemed to increase the number of adults staying on the steer. A new stanchion and urinal improved the sanitation of the adult-rearing room. Better control of the moisture content of the feces was obtained by replacing 25 percent of the alfalfa hay for the steer with sudan grass hay.

The dry artificial rearing medium consisted of 264 parts (by weight) ground sugarcane pulp, 48 parts whole wheat flour, 36 parts fishmeal (60 percent protein), and 6 parts sodium bicarbonate.[7] Before use, 1,100 milliliters of water and 0.28 milliliters of 6 percent sodium hypochlorite were added for each pound of dry medium.

To determine the optimum use of artificial medium, feces containing horn-fly eggs were held for 24 hours, and 5-pound lots were mixed with the dry medium at ratios of 20:1, 10:1, 5:1, 2:1, and 1:0, with water being added during mixing. The resulting media were held in 12- by 16-inch by 6-inch deep enamel pans for larval development. The manure containing artificial medium produced more and significantly heavier pupae (table 3). The mean pupal weight was greater than in any of the previous tests, and over twice as many pupae were produced for each gram of feces.

Two experiments were conducted to determine the optimum time to hold the feces containing horn-fly eggs before mixing them with artificial medium. In the first experiment, feces were collected at 4-hour intervals throughout the day and mixed with artificial medium 4, 8, 12, 16, 20, and 24 hours after collection. The mixture consisted of 5 parts feces, 1 part dry medium, and 2.5 parts water by weight. The mixture was held in 12- by 16-inch by 6-inch-deep enamel pans for larval development. The results of this experiment indicate that survival may have been reduced by mixing 4 and 8 hours after collection. The second experiment compared the production of pupae from 24-hour collections when mixed with the artificial medium at 0, 24, and 48 hours after collection. The feces were collected at 4-hour intervals, beginning at 0800, and held separately until all the feces for a 24-hour period were combined and mixed with artificial medium. The 24-hour holding period resulted in the greatest production of pupae. Both the daily production and the density of pupae in the feces were greater in this experiment than in previous experiments (table 4). Collection of feces at short intervals, with smaller piles of feces, may

TABLE 3.—*Effects of mixing artificial medium and feces on the production of horn-fly pupae*

Ratio of manure to dry medium	No. trials[1]	No. pupae/ trial[2]	Pupal wt.,[3] mg	Pupal density, No./g feces
1:0	8	1,365	2.9	0.60
2:1	6	2,774	4.0	1.22
5:1	9	2,913	3.7	1.28
10:1	5	2,512	3.5	1.11
20:1	3	2,144	3.5	.95

[1] Calculations based on 5 pounds of feces for each trial.
[2] Differences among numbers of pupae were insignificant.
[3] Differences among pupal weights were significant at $P=0.01$.

[7] Harris, R. L., Frazar, E. D., and Grossman, P. D. 1967. Artificial media for rearing larvae of horn flies. J. Econ. Entomol. 60 (3): 891–892. See also Schmidt et al. (1968), cited in footnote 6.

TABLE 4.—*Effects on pupal production of mixing artificial medium with feces at various times after oviposition*[1]

Age of feces and eggs when mixed, hours	Feces wt., kg	No. pupae	Pupal density, No./g feces
0–24	10.8	19,668	1.82
24–48	11.5	33,328	2.89
48–72	8.8	27,902	3.17

[1] 5 trials at each age.

TABLE 5.—*Summary of trial production, July–August 1972*

Variable	Avg.
Feces wt. ....kg........	10.6
Medium wt. ....kg........	17.9
Pupal production ....No./day........	24,822
Pupal wt. ....mg........	3,552
Pupal density:	
No./g feces	2.34
No./g medium	1.39
Adult population	6,457
No. pupae/day/adult	3.84

have increased survival during the early stages of development.

Production Test

Procedures determined during all earlier experiments with the rearing of horn flies on steers were combined in a production test in July and August of 1972. Before and during the test, 1,000 pupae were placed in the steer room daily, allowing the adult population to reach and maintain an equilibrium. The host steer was kept clipped. Collection intervals were 24 hours long, beginning at 0800. Overnight collections from Monday through Thursday evenings were made on a conveyor, covered with plastic film, which moved at 4-hour intervals so that the droppings did not accumulate in deep piles. On Fridays, Saturdays, and Sundays, the overnight collections were made on single stationary trays. The collected feces and eggs were held for 24 hours and then mixed with 1 pound of dry medium and 2.5 pounds or more of water for each 5 pounds of feces. The mixture was placed in 12- by 16-inch by 6-inch-deep pans with no more than 10 pounds in each pan. Observations made during the test included daily population counts, percentage emergence of adults, initial weight of feces, number of pupae, and weight of pupae.

The results of the trial production test are summarized in table 5. For 46 days, the average daily production of pupae was 24,822. The maximum daily production was 47,734, with the average pupal weight declining to 3.15 milligrams on that day. On only 1 day did production drop below 10,000, and that occurrence was probably due to improper mixing of the feces and dry media. The emergence from pupae produced during the test was 86 percent, indicating that 860 emerged flies per day had a mean life of 7.5 days, resulting in the average adult population of 6,457. The data for the feces collected overnight on trays were compared to those of the feces collected on a conveyor, indicating a slight production advantage for the conveyor of 25,625 to 23,777 pupae per day.

The effects of adding artificial medium to the feces for larval rearing are shown by comparison of the dash line and the solid line in figure 1. The dash line shows the linear regression function of pupal density versus pupal weight for the data from the trial production run, and the solid line shows the same function computed with the data from 1971, when only feces from the host steer were used as larval-rearing medium. With the mixture of feces and artificial medium, the pupae were substantially heavier at the greater population densities. The improvement in pupal weight with the addition of artificial medium may have been due to both improved nutrition and to improved circulation of gases through the lighter and more porous mixture of feces and artificial medium.

CONCLUSIONS

Several procedures used for rearing horn flies on cattle are listed below. The benefits of some of the procedures are not documented by research data, but they should be considered for further work on rearing horn flies.

1. Good ventilation and sanitation were required in the rooms containing the adults.
2. A room temperature of 75° to 80° F seemed suitable for the adults.
3. Alfalfa and grass hay for the steers provided suitable feces for the larvae. Grain in the diet depressed larval production, but some